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ABSTRACT

This speech reports the recommendations of the National Science Board Commission on Pre-College Education in Mathematics, Science, and Technology. The commission was appointed to develop an action agenda for reversing the current decline in student achievement and participation in the area. The commission's 20 members, drawn from all sectors of society, produced a two-volume report giving specific recommendations for the Federal, State, and local levels and providing estimations of Federal money required. General goals set by the commission for the entire educational system were (1) to include math, science, and technology in the lifelong learning of all citizens; (2) to enable all our youth to develop a useful knowledge of these subjects; and (3) to strengthen the quality of professionals in these fields as well as to recruit more students from underrepresented groups. Specific recommendations were made for improving national, State, and local leadership in education; monitoring student achievement and participation; training and retraining math and science teachers; creating more magnet schools; redefining the math and science curriculum; and improving opportunities to learn through, with, and about computers. (CB)

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ADDRESS DELIVERED AT
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It is my pleasure and privilege to represent the National Science Board Commission on Pre-College Education in Mathematics, Science and Technology. Our group was convened in April 1982 by the National Science Board - the policy making body of the National Science Foundation, in response to their concern over the marked decline in student achievement and participation in mathematics, science and technology. This decline was defined in crisis terms because it was occurring at a time when societal conditions and jobs are generally acknowledged to be more and more technologically oriented, when technological and scientific literacy are required for a healthy and informed citizenry, and when innovation in science, technology and in its management is increasingly seen as a touchstone of our future.

The National Science Board charged our Commission with developing an agenda for action by all sectors of society to reverse this decline. This we accomplished, and ahead of schedule, in order to be available to the Congress before its November recess. Immediate reactions have welcomed and honored the specificity with which we have defined the commitments of money, time and talent needed to reach our educational objectives. Ours is an action plan and covers many issues not touched in the many other reports and studies that have burgeoned lately--and the only one to estimate Federal dollars required. We focused on mathematics and science, as we were

asked to, but always considered our subjects in the context of all learning and believe that many of our recommendations could be equally well applied to other areas of study.

There are two volumes to our report:

The first includes the executive summary, the report itself and 5 exhibits. The second volume of source material reports on 6 working groups commissioned by our various task groups, and 4 other studies commissioned by us, including that of the Education Commission of the States, which summarizes the results of a 50-state survey of initiatives in science, mathematics and computer education.

The Commission had 20 members, distinguished leaders drawn from virtually all sectors of society -- state and local governments, business and industry, pre-college and higher education, teachers, the professional science and engineering communities, the military, the media and the law. The concensus reached reflects the interests, needs and priorities of the various specialities and sectors represented by all commisioners. I believe our recommendations to be valid and realistic, both politically and educationally. The concensus they represent came only after intensive study and challenging dialogue and should represent the concensus possible in any such diverse group -- the concensus essential to move us collectively ahead.

Our first and immediate concensus was on the goals we would set for our total educational system, both formal and informal. These are the objectives that we believe current

actions and strategies should work toward :

1. Mathematics, science and technology will be included in the heightened expectations and objectives now being developed of general literacy for all citizens -- to start in school but be maintained through lifelong learning. Mathematics, science and technology as exploration of ideas and observations are thus integral to language development.

2. Our resources of people and of material, of time, talent and money will be mobilized to enable all our youth to develop a useful understanding of mathematics, of science and of technology.

3. We will not only maintain and strengthen the outstanding quality of our leading scientists, engineers, doctors and teachers but will also recruit many, many more students from currently under-represented groups into this pool so that the best and brightest in these fields will become broadly representative socioeconomically, geographically, and by race and gender of our total population.

These expectations, these objectives are new to the nation, but essential to its continued health and vigor. They are possible if there are new commitments and new strategies at the federal, state and local level. Our report spells out in considerable detail the requirements of such leadership and, because we deemed it irresponsible to call for actions without

estimating their costs, we estimated the costs at the federal level of the actions we recommended. Recognizing the magnitude of the tasks involved to improve and change the conditions of the education of our youth, and at the same time to move the nature of what is learned and taught to new objectives in mathematics and science, we suggest a time frame for action that is sufficiently long to allow accomplishment of the required actions and sufficiently short to maintain motivation and momentum.

To understand the newness of these objectives and expectations one need only look at the instruction, in mathematics and science that is now most prevalent in schools. It is geared to attitudes of previous generations -- notably that understanding of mathematical and scientific observations and theories need only, and can only be sought for the pre-professional and academically elite student- while technology, the study of how we use science, is most appropriate for the vocationally oriented, for utilitarian education. As indicated by other reports, that we enthusiastically endorse, a core of "higher order" skills and understanding is the right, the need and within the capacity of all students. To put this in different terms, our traditional Jeffersonian and Jacksonian tracks of education must now be melded, and a new (perhaps recombinant!) form produced. For important changes, important strategies are needed: politically, economically and educationally. The major ones we recommend are:

- o A time frame within which the necessary steps could be completed: We chose 1995 as a reasonable target--the date when this year's first graders will complete high school.
- o Ongoing strong and committed national leadership: We suggest a National Education Council appointed by the President and reporting to him as the optimum strategy and we outline in some detail both the role, function and cost of such a Council,

- o Comparable leadership at the state level such as the Governors' Councils established already in many states: To develop broad-based leadership and support integrating business, academic leadership and other leadership with that of the public education system.
- o Leadership at the local level--through school boards and their partnerships with business, government and academe and/or additional local councils which may be necessary in some situations.
- o A comprehensive, nationally supported and maintained mechanism for measuring student participation and interest so that those responsible can monitor progress toward goals that are set and so that schools have necessary and useful information for planning and for making appropriate mid-course corrections.

Thus we see the need for both "top-down" and "bottom up" leadership. The national level should provide information, guidance, some financial support, the capacity for collaborative leadership with all sectors and for networking and dissemination to schools, teachers, communities. The local level should create the programs and activities to fill the needs of their students, but maintain, with the help of national and state councils, close communication on all issues (i.e., curriculum and computer software for both students and teacher training, materials development, exemplary programs development), with other schools and systems both within and without the state. The national assessment mechanism and the national leadership specified for educational technology, curriculum and teacher training all become mechanisms to assist local leadership and enable it to access the best resources available.

These are primarily political strategies--means to the student outcomes hoped for. But what are the educational outcomes, the educational objectives sought? The single most important sentence in our entire report may well be the following, from the Introduction, "The Commission has seen convincing evidence that all students with the capacity for learning in general subjects can develop a useful understanding of mathematics, science and technology, if these subjects are appropriately and skillfully introduced at the elementary and secondary school levels."

This audience must be all too familiar with the observation that early identification of mathematical and scientific talent leads to early opportunity and early advantage, which then compounds year by year to create an ever-widening gap between those students awakened early to good mathematics and scientific interest and confidence and all others. If we are to develop inherent talent, self-confidence in problem-solving and interest in science in all our students--including the socioeconomically deprived, we must find ways to expose all children to the most stimulating, culturally-rich, aesthetic, comprehensive, early instruction in science and mathematics. Only through such approaches can we even dream of equal opportunity for all to participate fully in these fields and thus to enter into the meritocratic domain of scientists and mathematicians or to continue study throughout schooling to develop scientific literacy. A focus on all students and on their vastly improved early introduction to "higher order" skills are the first listed educational recommendations of the Commission. "Excellence and elitism are not synonymous."

The essential strategy underlying all education is the quantity and quality of teachers, and thus we recommend another top priority:

- Retraining, obtaining and retaining teachers of high quality in mathematics, science and technology, and providing them with a work environment in which they can be effective.

To underline the current critical need, we call for federal financial support and suggest a five-year time frame for completion of a period of intensive retraining ("renewal" of all secondary mathematics and science and most elementary teachers).

Detailed recommendations are presented regarding the roles and relationships of government, academe, professional leadership and business in improving teacher preparation and the working conditions and status of teachers. We note the particular potential of Science and Technology Museums for a range of teacher education programs. Overall we make it clear that the goal is to have an ongoing capacity for continuing education of all teachers in place and with appropriate financial support at the end of the five-year period.

Another key strategy for improvement is the development and support of models for change (exemplary programs and exemplary schools). We were very impressed, as we visited some communities and read testimony from others, with the positive effect of magnet schools and other specially designed programs, including intervention programs designed to involve women and minorities more productively in the sciences.

The "ethos" of a school or any learning environment is a major determinant of the quality and quantity of learning that takes place. In some school situations the leadership and personnel are such that improved learning environments can be

created as part of the ongoing operation of the school. In other situations, notably in inner-city situations, a positive environment cannot be created without terminating the old environment or school and starting fresh. Hence the strategy of creating the new school as a "magnet" school.

As part of the strategy, originally designed to assist integration, a speciality is designated for the school such as the arts, or science and mathematics or a career orientation such as the medical or business professions. Most magnet schools require only demonstrated motivation and commitment for admission.

There are about 1100 "magnet" schools in the U.S. now with approximately 75% at the elementary level. They vary greatly, but do appear to help prove that all children can learn. They demonstrate to communities, now grown cynical through tales of school failure, that schools can succeed - that there are plenty of "good guys and gals" around.

For these reasons, we recommended the development of at least another 1000 of these schools at the elementary and at the secondary level and called for major federal expenditure, on a 65/35 matching basis, to lead the effort. The wording of our recommendations for federal and state leadership in encouraging, financing and promoting such schools and programs emphasizes that they should "serve as examples and catalysts for upgrading all schools."

In summary, we recommend that top priority be placed on: a focus on all students, improved and more intensive higher standards and more time throughout early exposure, teacher

training and developing more exemplary programs and schools as catalysts. But what should be taught and learned through these strategies? There are new conditions for mathematics and science education, which mandate new goals, new objectives.

People are most effectively motivated by emphasizing the positive, by building from strength. I suggest that we emphasize the newness of the educational objectives now needed. Our failure in meeting these objectives arises from their newness--not our incapacity. We have not done so badly in meeting the old objectives of science and math as relatively elite subjects useful for those pre-motivated for a professional track, or the objectives of improving "lower-order skills" for those in the lowest socioeconomic groups. The reasons for new objectives are as follows. First, as already mentioned, we must provide resources and capacity for <u>all</u> students to develop a useful understanding in science, mathematics and technology, and for all students to have the early opportunity to develop "higher order" skills and talents.

Secondly, groups such as those that met at Commission invitation, and the Commission itself, agree that there is now something called technology education which must be included throughout the elementary and secondary curriculum as an integrating factor between science, math and society-- and also with art, music, social sciences, languages.

Adding a dimension to these needs for a new definition of what is taught and learned are other critical factors:

- The explosion of knowledge in all fields of science and in new and emerging technologies leads to new definitions of what is fundamental, i.e., what should students know--and why. Symbolic of this is the title used by the Conference Board of Mathematical Societies in their report to us (Volume II), "What is Still Fundamental and What is Not."

- The escalating availability and usefulness of new communication and educational technologies. Computers, videodisc, videotext, telecommunications.
- The promise for education resulting from recent work in the social and behavioral sciences--helping teachers to understand how children learn, and to design their teaching methodologies with this knowledge in mind. That the National Science Teachers Association has published several valuable documents, entitled, "What Research Has to Say to the Science Teacher," I find eloquent testimony to the potential here.
- The tendency of the present system to motivate only the already-motivated and pre-professional students to continue to study and enjoy the fields of science and mathematics. Issues of gender and socioeconomics here.
- The evidence that students come to school as natural scientists and mathematicians-- There is recent data, as well as parents' and teachers' intuitive understanding, that there is "mathematization" in all child-

ren-- but they are "turned off" early in the elementary grades either by poor teacher preparation and attitude and/or by lack of family or community support.

Thus we have new conditions and new goals, all of which hang on a fresh understanding of the essence of the mathematics and science that is to be communicated. Mathematics is a way of thinking that opens doors to new knowledge in virtually every field of learning and not just simply computing. Science is "imagination in search of verifiable truth", exploration and fascination with the unknown and not just simply a hierarchically organized body of "known facts" that yield irrefutable answers. Technology is not just computer education, it is exploration of how we use science, how science affects society and vice versa.

Mathematics does build rigorously on prior knowledge and experience and must be dealt with in certain sequences. Science covers so much that teachers should be free to identify topics they know and enjoy and that are appropriate to their students and free to deal with these with some rigor rather that feel there is any gospel to "cover." As our report states, "The nature of scientific inquiry and observation presents frequent opportunities for experiencing success with original ideas. Such inquiry does not require unique answers. Students can rightly and successfully report what they have seen and found. This type of experience should be encouraged."

And we do talk about encouragement and development of innovative thinking. I am greatly surprised that in the current

surge of educational rhetoric, reports and studies, innovative and creative thinking is scarcely mentioned. Our political, higher education and business leaders are busy with efforts and programs to maintain and improve American technological innovation, and technology transfer -- transfer of innovative ideas into marketable products. Development of innovative thinking and acting in students before they enter college or graduate school is included in the defined educational objectives our report recommends.

To turn, finally, to the topic generally thought of in association with technology today: learning through, with and about computers. In our view, learning through computers has, by far, the highest potential for helping students. Recognizing all the existing problems in ensuring the optimum introduction of computers into schools and the need for vastly improved software development in tandem with curriculum development, we suggest that there must be new ways for the private sector to work with both the formal and informal aspects of education. We call for a meeting of chief executives of major and representative hardware and software (including publishers) companies to explore how they can help the educational system adapt and grow with the growth of technologies.

The National Science Board Commission indicated, by the depth and breadth of its recommendations, its awareness of the magnitude of the commitment needed. Only through finding ways to introduce all our children to stimulating and com-

prehensive mathematics, science and technology can we dream of equal opportunity to develop an understanding of these subjects that is useful, that encourages lifelong learning for an educated citizenry and the nurturing and development of the special talents our nation needs. To quote the report, "At stake is the quality of life of the next generations of Americans."